on detecting assembly bias of massive galaxies and clusters

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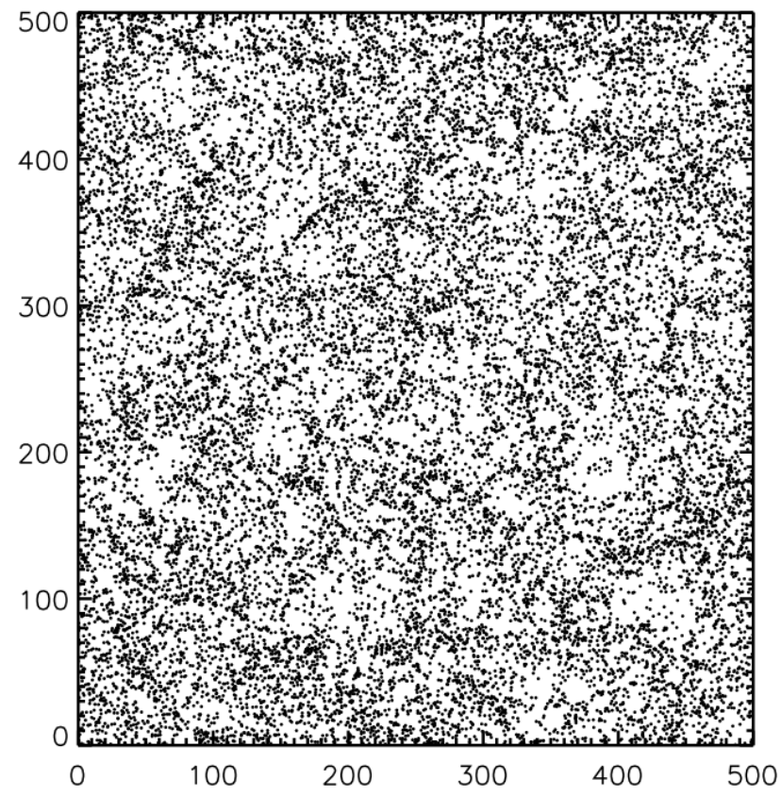
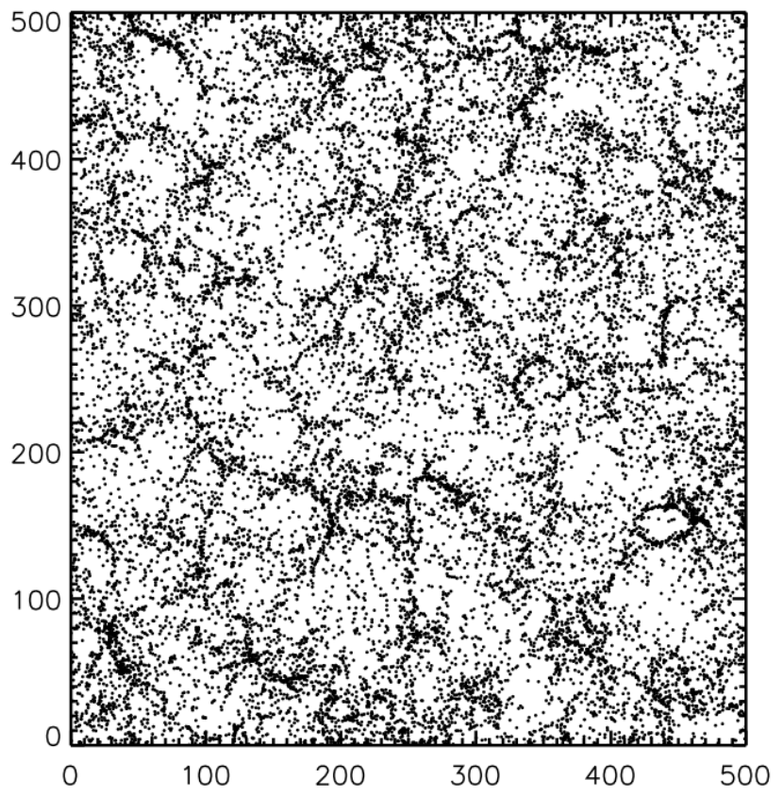
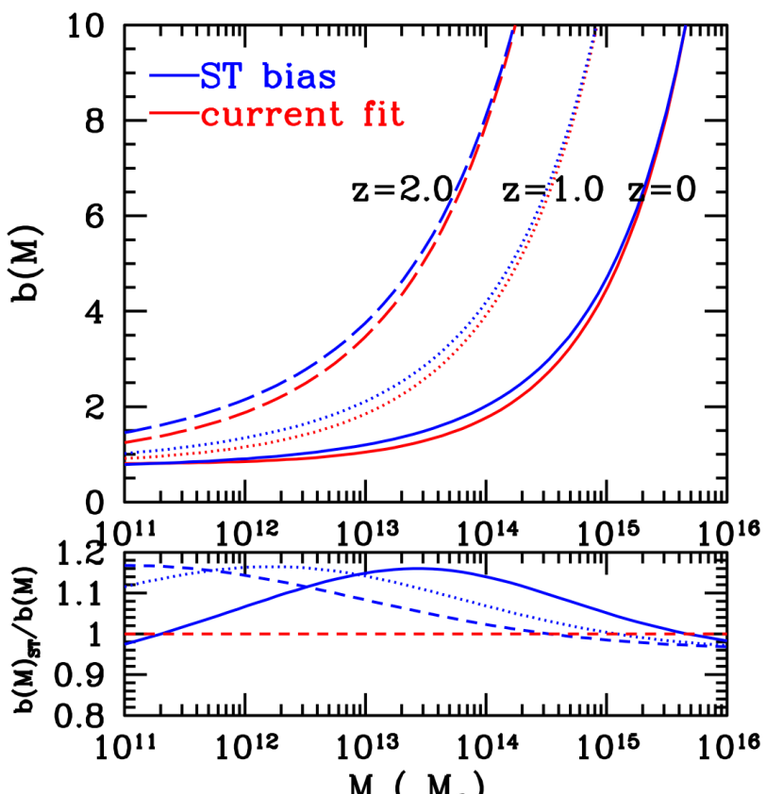
assembly bias?

- dark matter halos also have various degrees of bias, primarily as a function of halo mass
  - more massive halos are more biased
- a secondary effect is *assembly bias*: bias also depends on the halo formation time
  - for low mass halos (~$10^{12} h^{-1} M_{sun}$), those that form earlier would cluster more strongly (having ~40% larger bias)

Gao+05, Bhattacharya+11

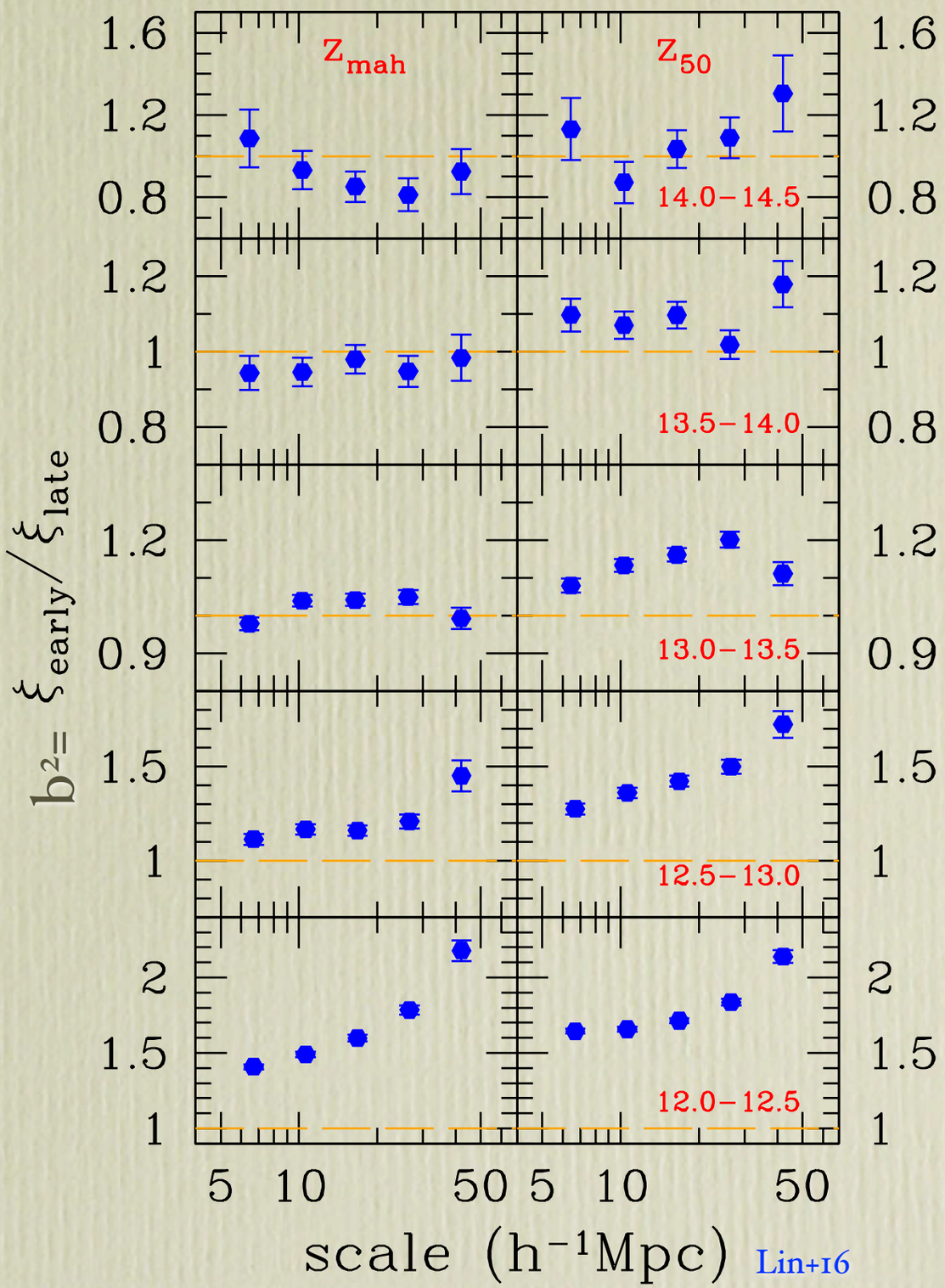






how big is it?

- amplitude of assembly bias depends on both halo mass and formation time definition!
- use simulations of Diemer & Kravtsov (2014)
- z_{mah}: $M(z) \propto \exp(-\alpha z)$, $z_{mah}=2/\alpha-1$ (Wechsler+06) MAH = mass accretion history
- z_{50}: redshift when a halo has acquired 50% of its final mass
- with z_{mah}, see sign change at high mass end: younger halos are more strongly clustered
- not the case with z_{50}



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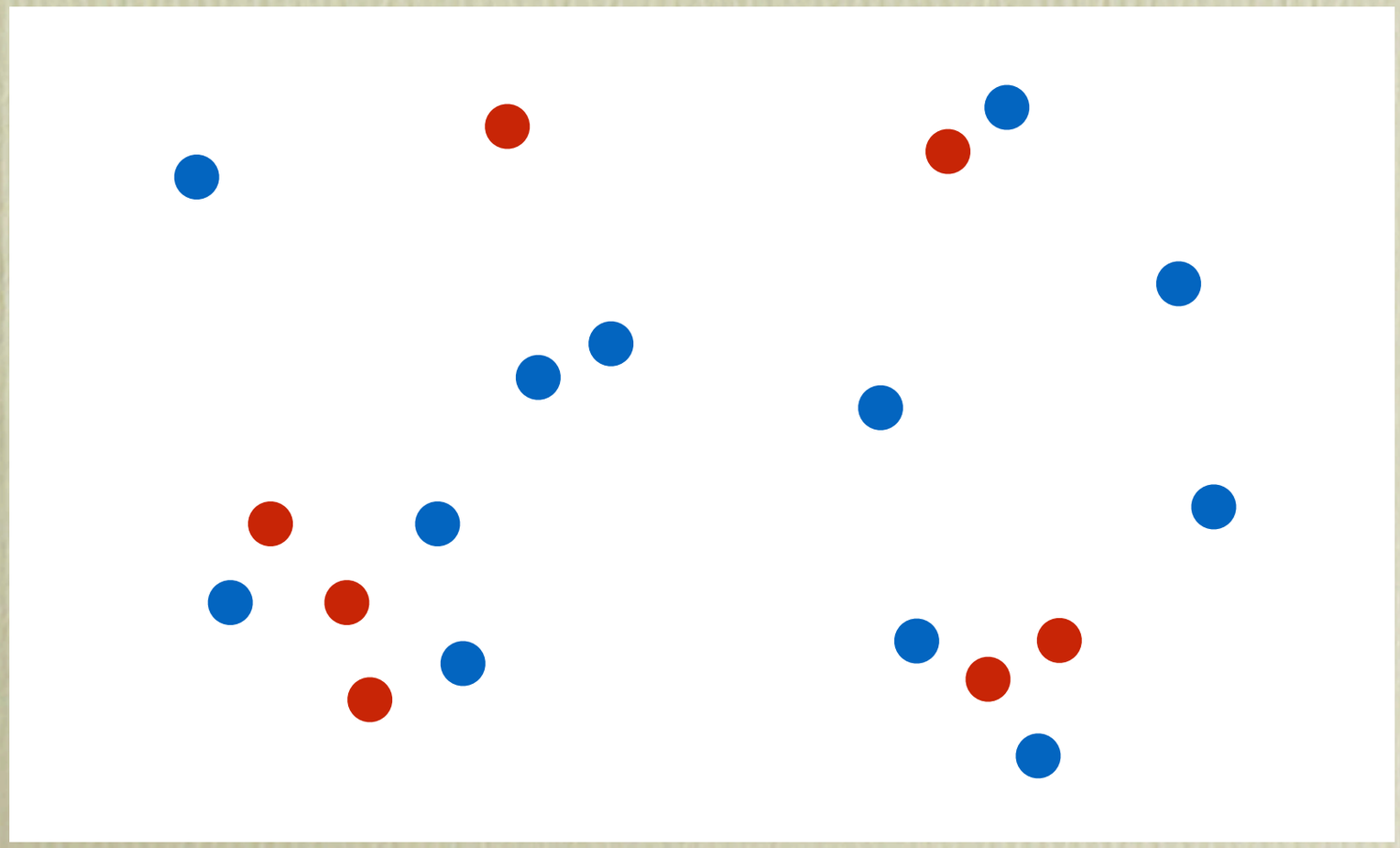
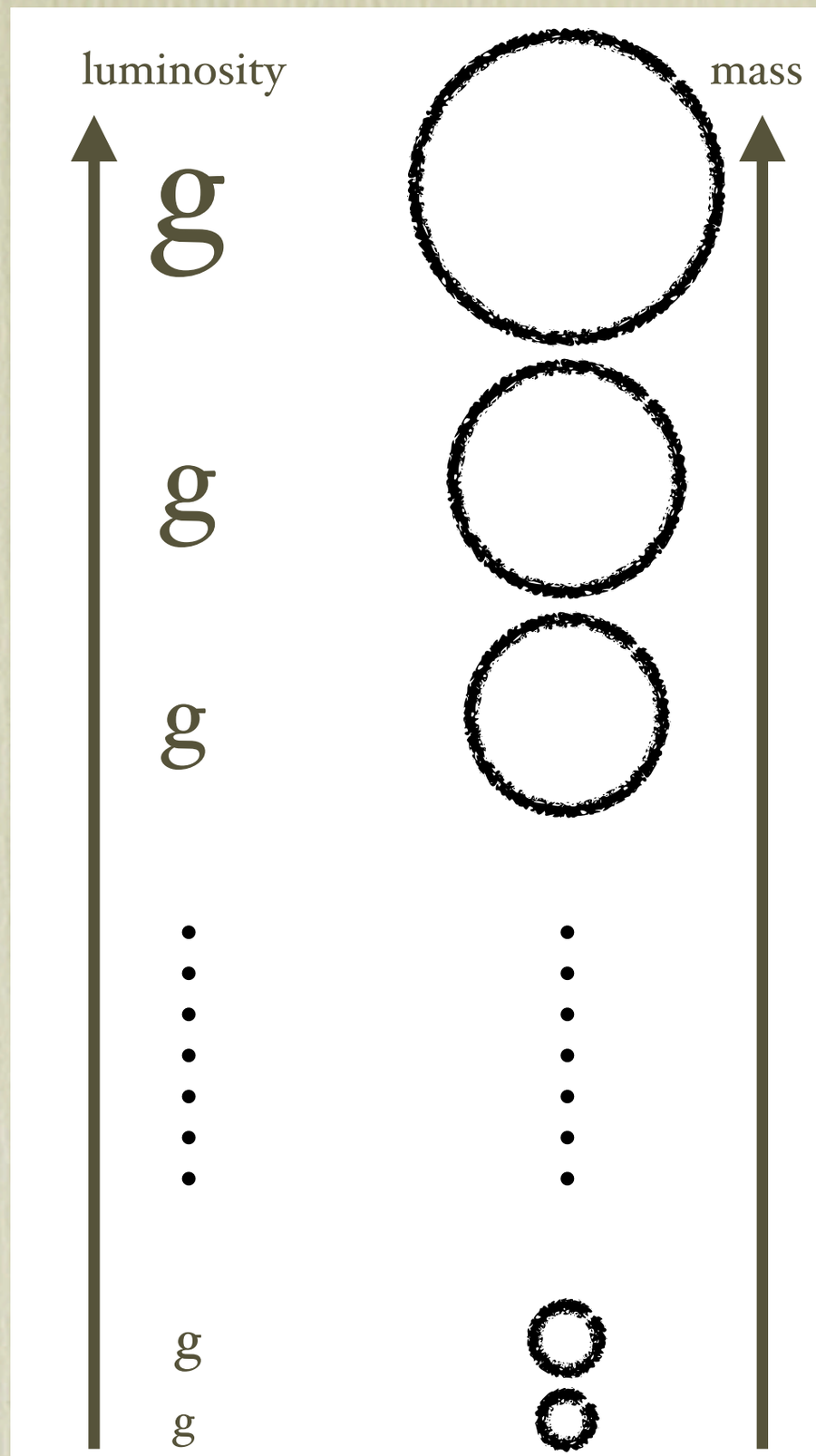
  - a catalog that classifies galaxies into single and multiple galactic systems
  - designation of central vs satellite galaxies
  - halo mass *assigned* to each system à la abundance matching technique





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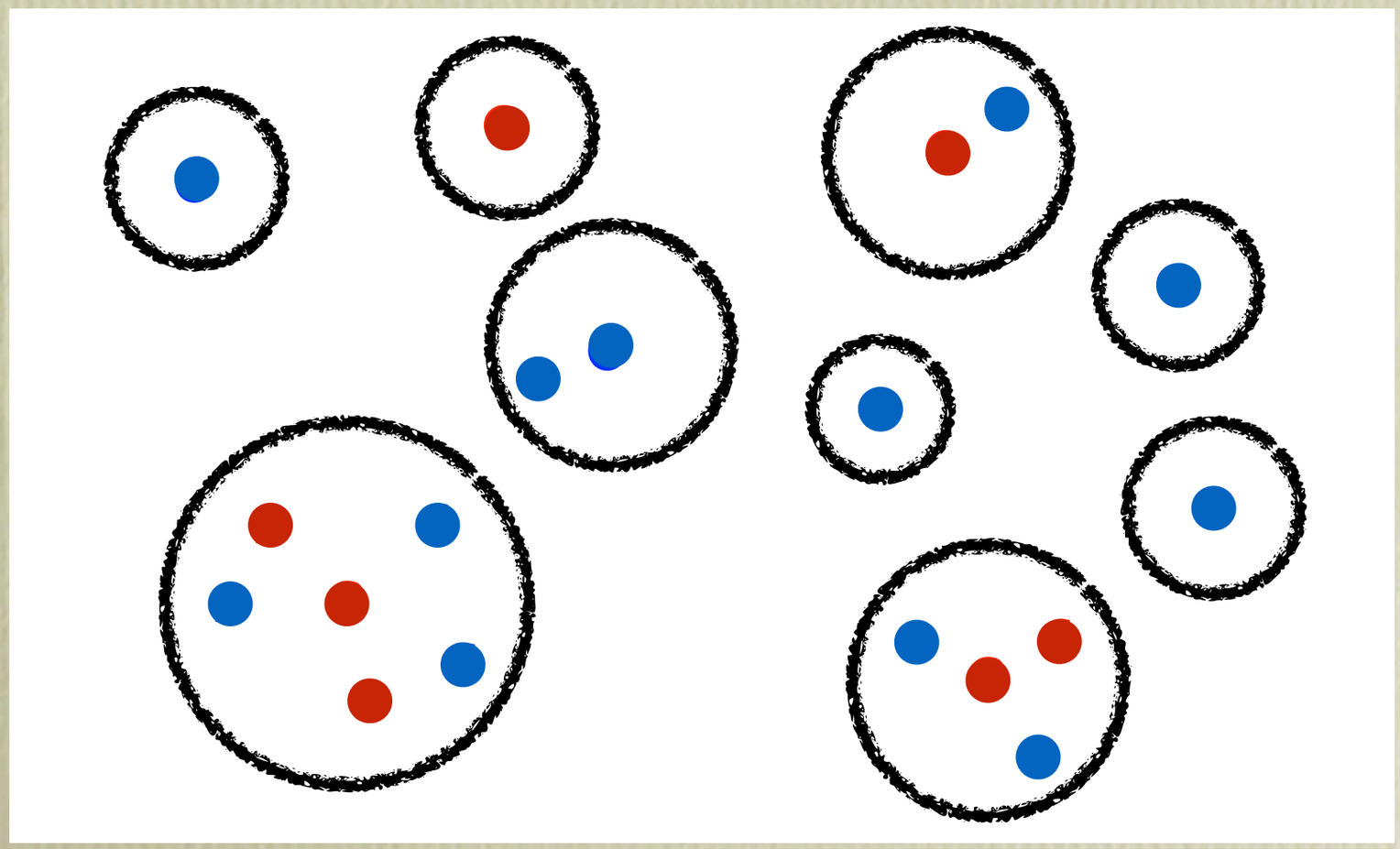

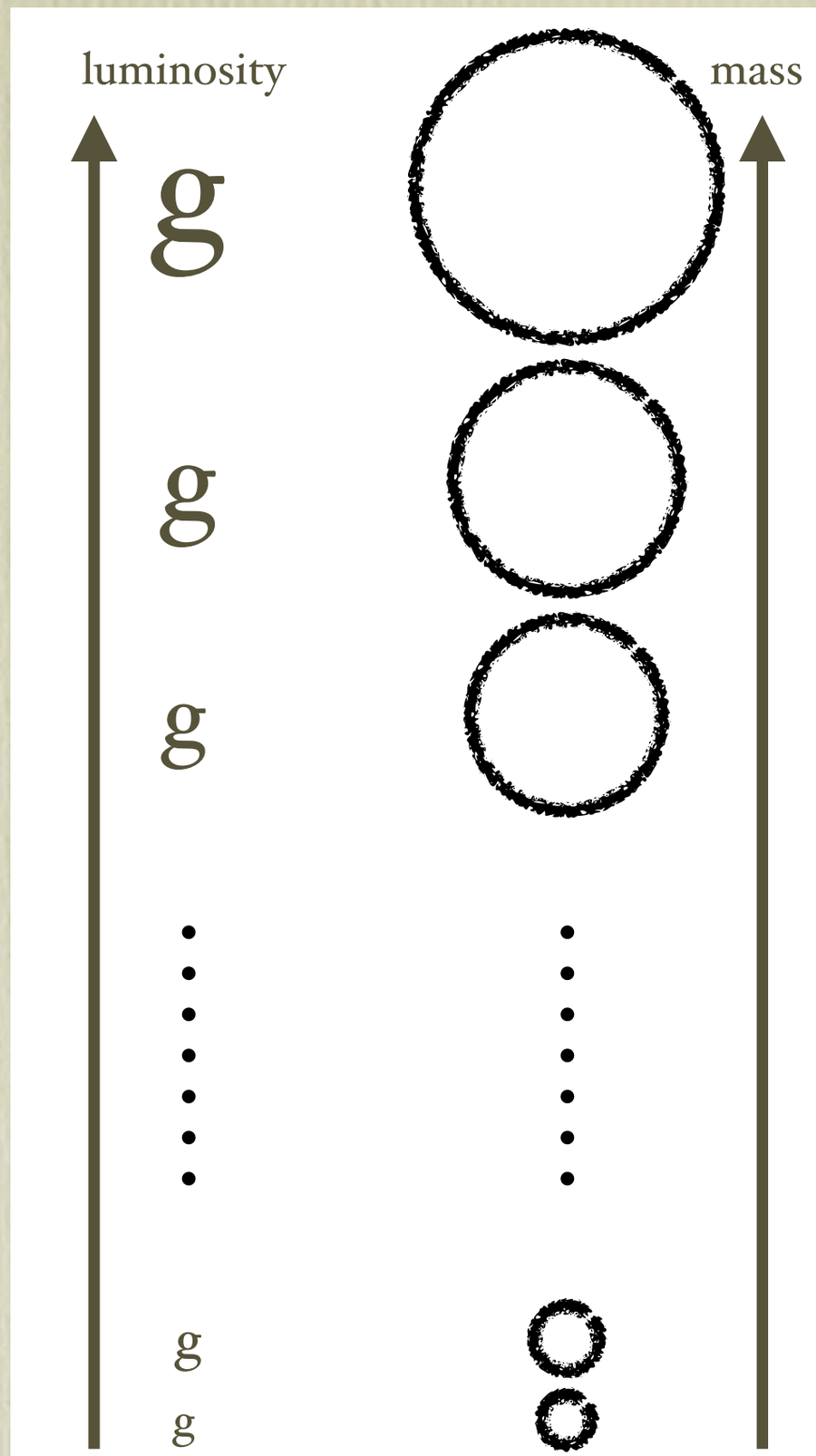

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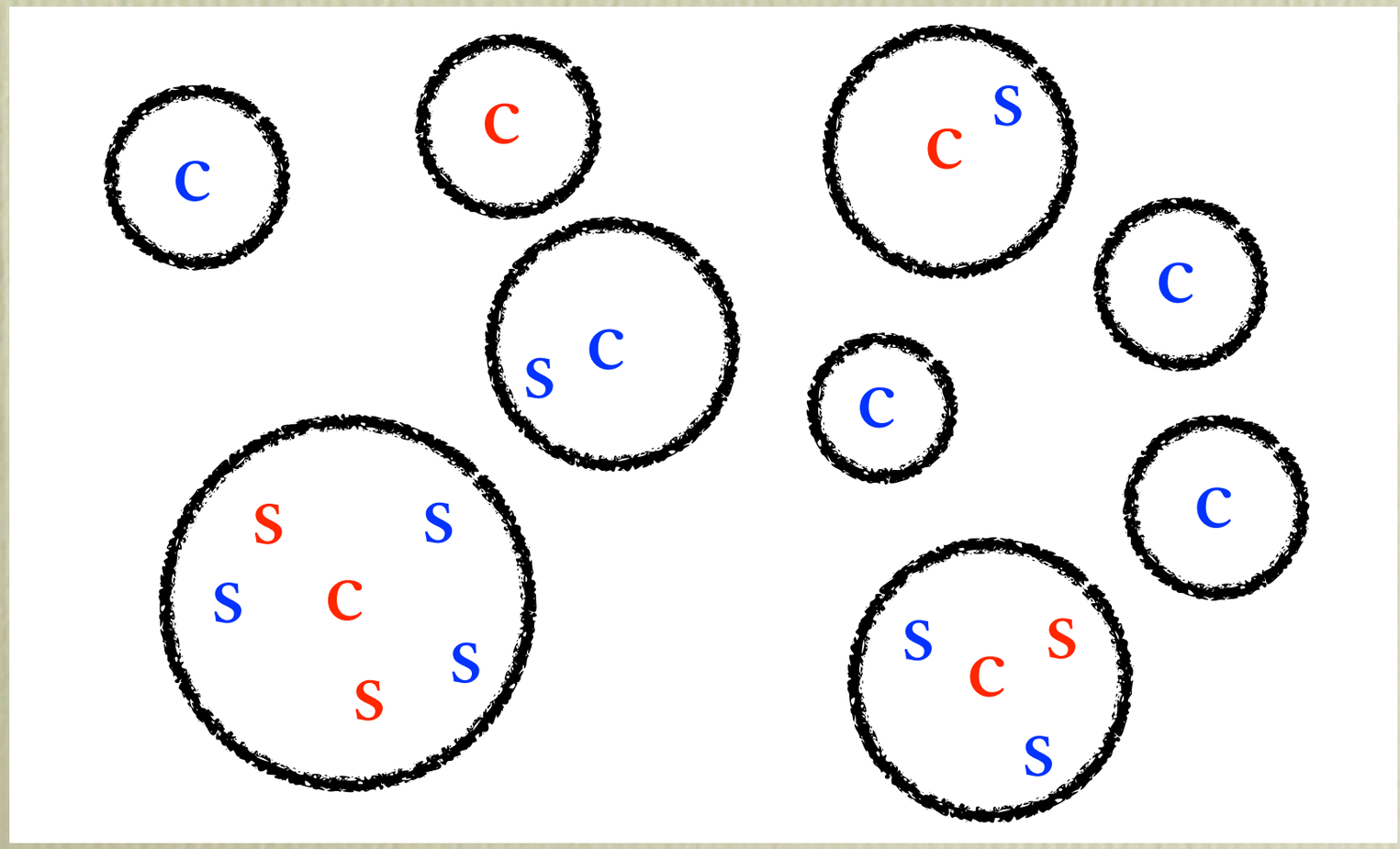

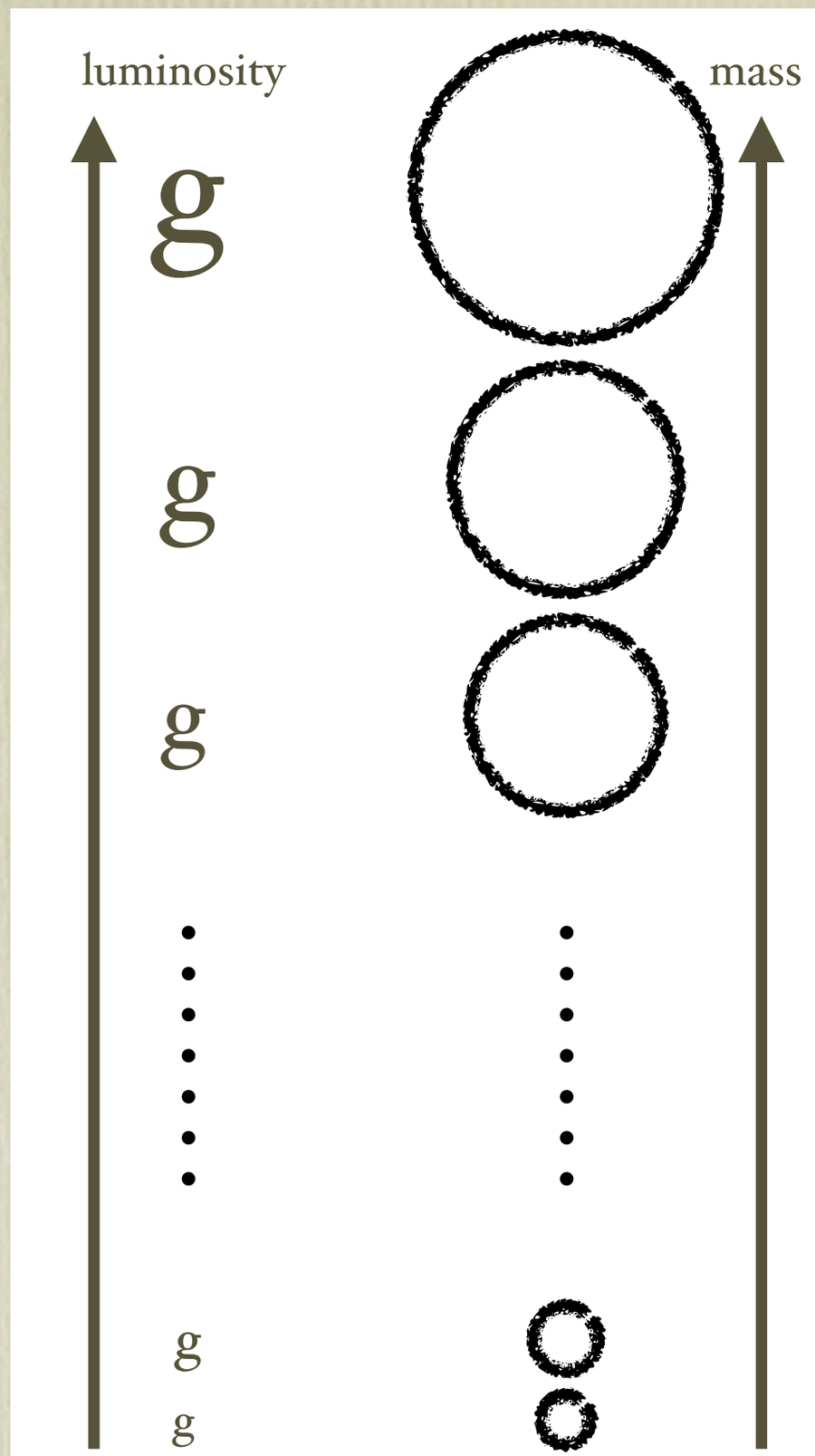

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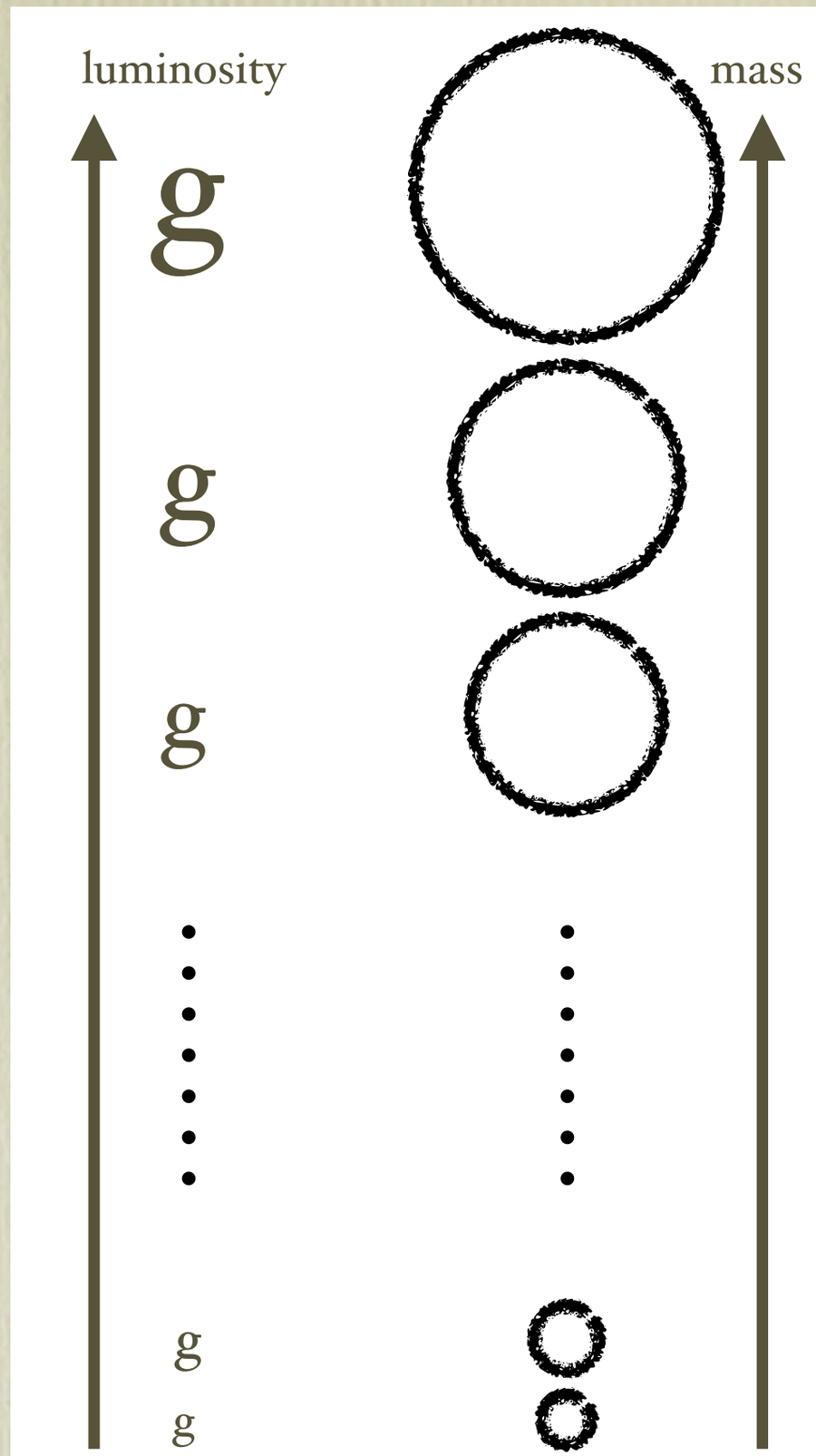
  - if passive ↔ old, star-forming ↔ young, then this indicated assembly bias



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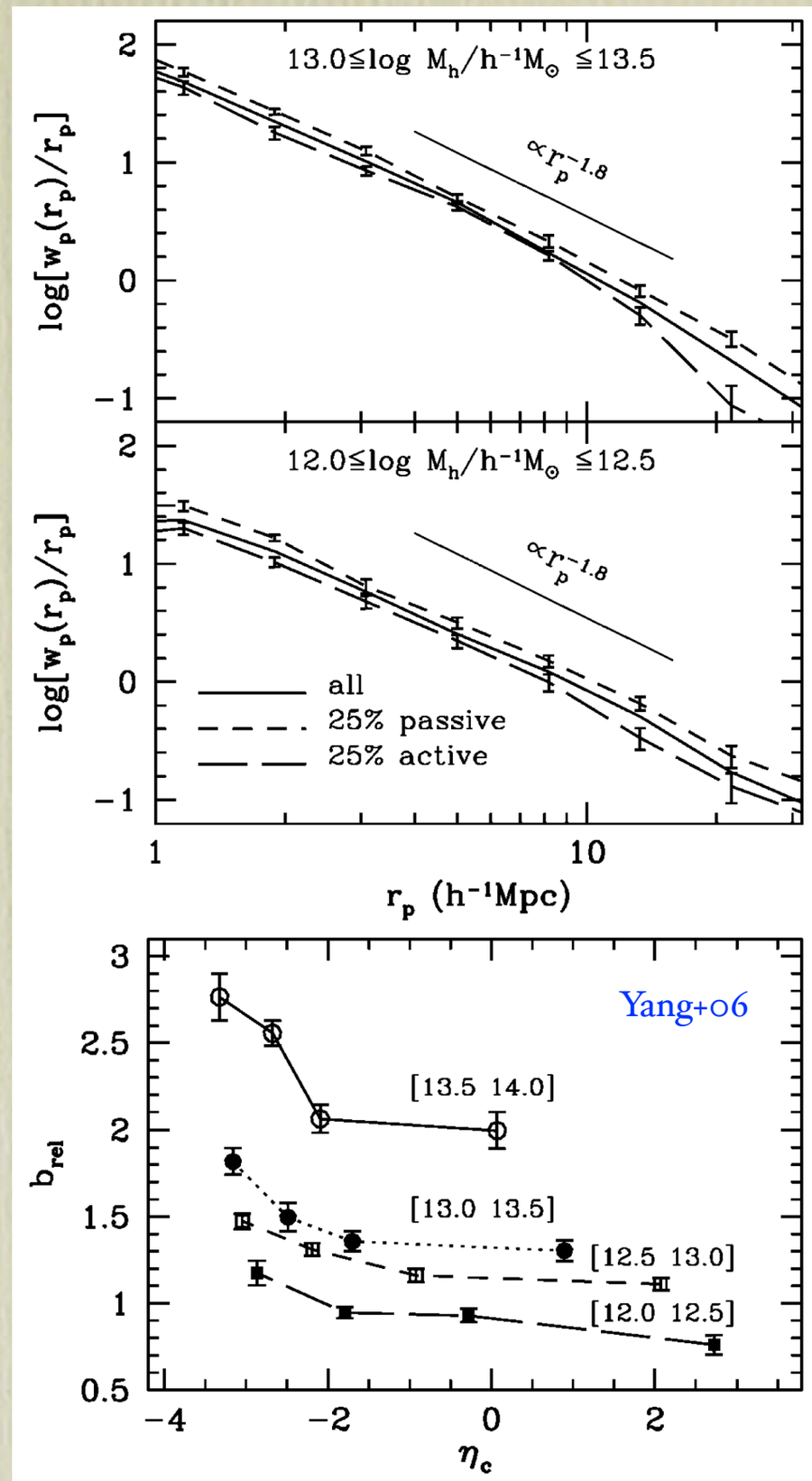
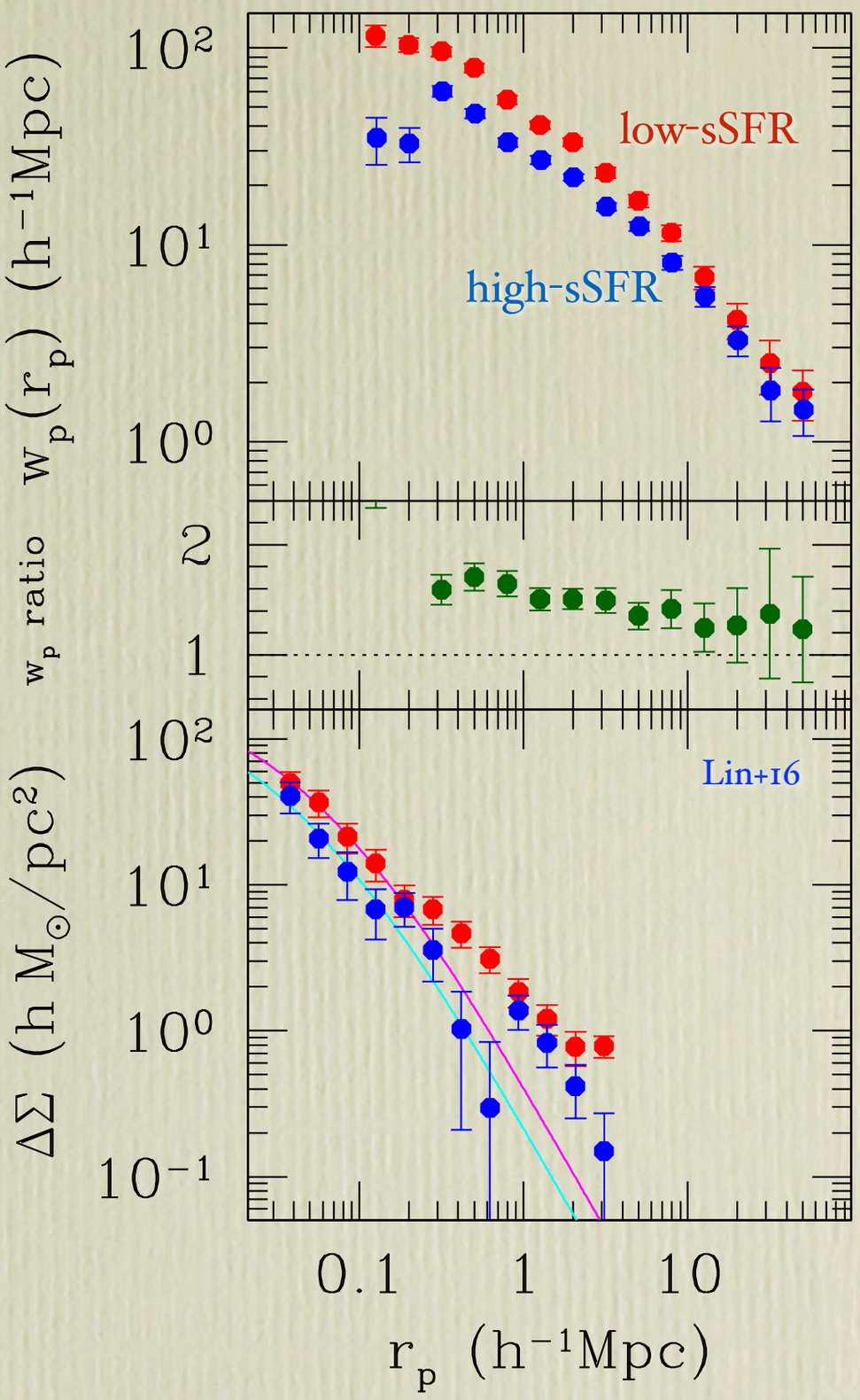


or was it?

- using SDSS data, we follow the Yang+06 approach and confirm that low-sSFR centrals do cluster more strongly than high-sSFR ones sSFR=specific star formation rate
  - only central galaxies are used
- however, the difference in bias may be explained by the difference in the mean masses of the two samples, as indicated by stacked weak lensing
- the previous claim of detection likely false
- Yang et al. halo mass assignment not reliable (at such low mass scales)
- serious contamination from satellite galaxies also seen



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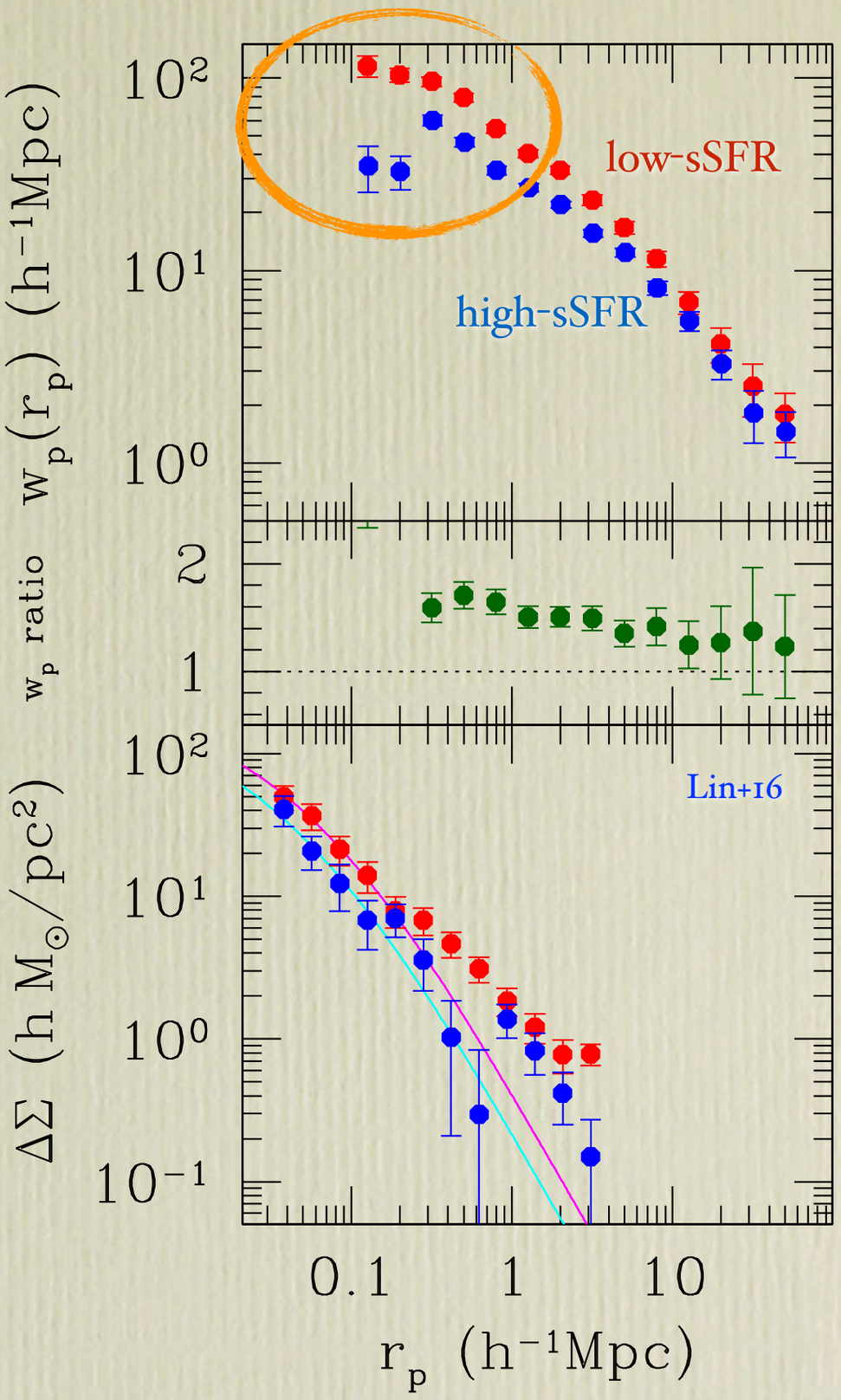

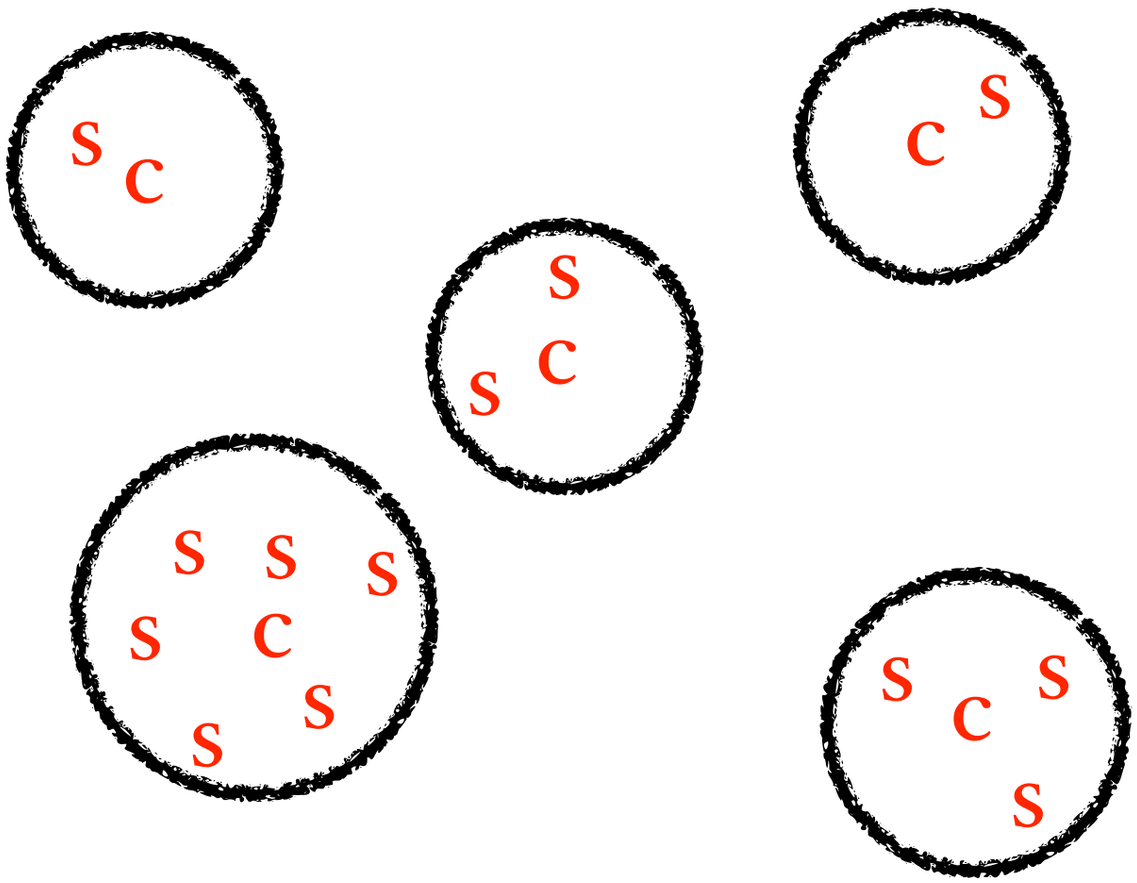
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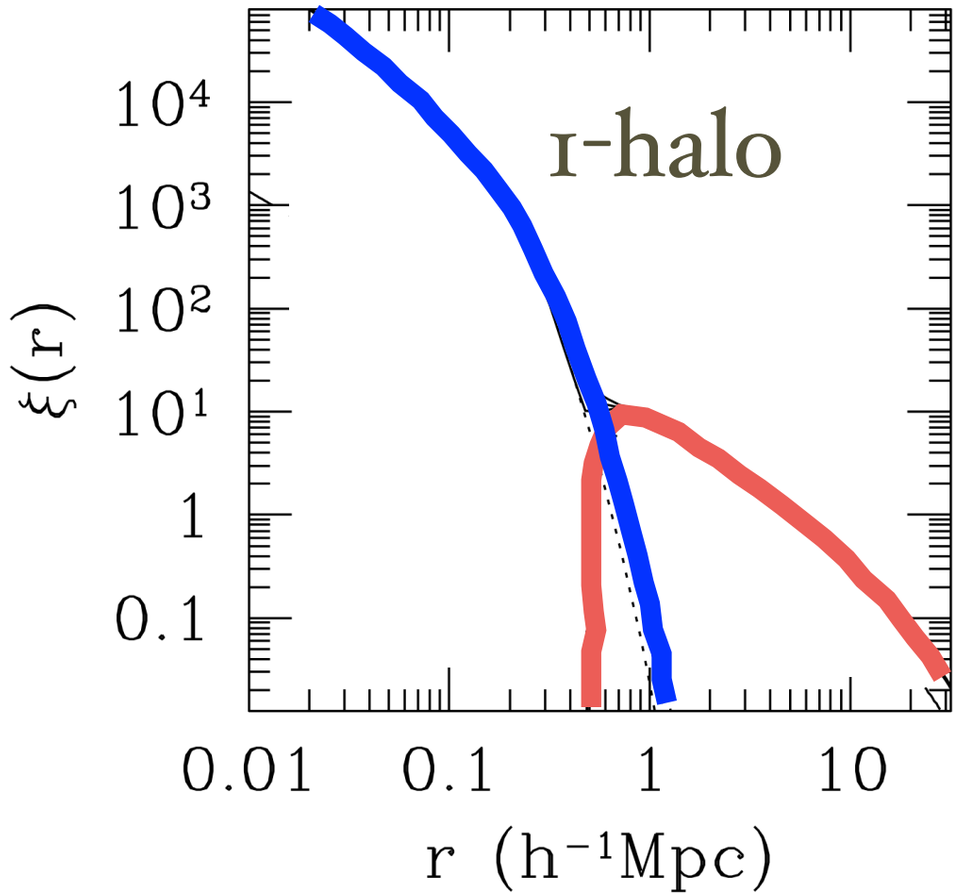
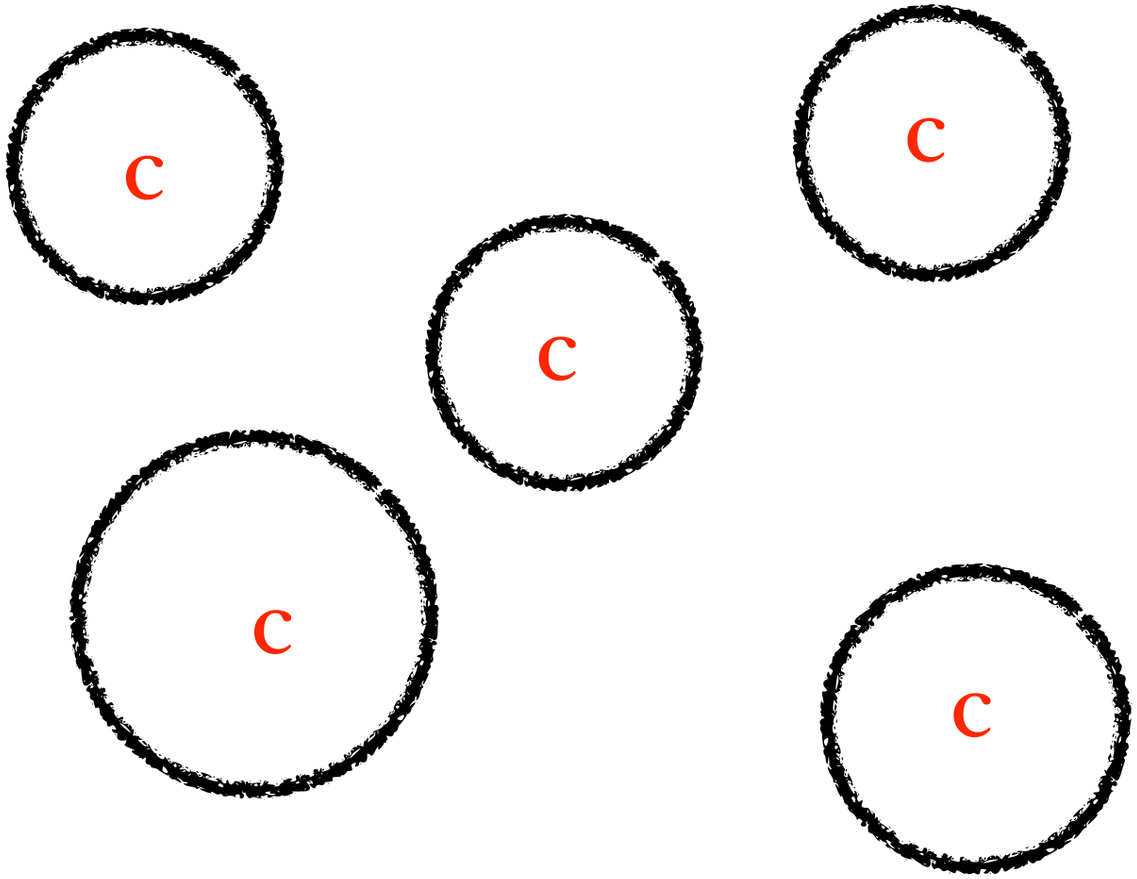

1-halo
10^4
10^3
10^2
10^1
1
0.1
$\xi(r)$
0.01
0.1
1
10
r (h^{-1}Mpc)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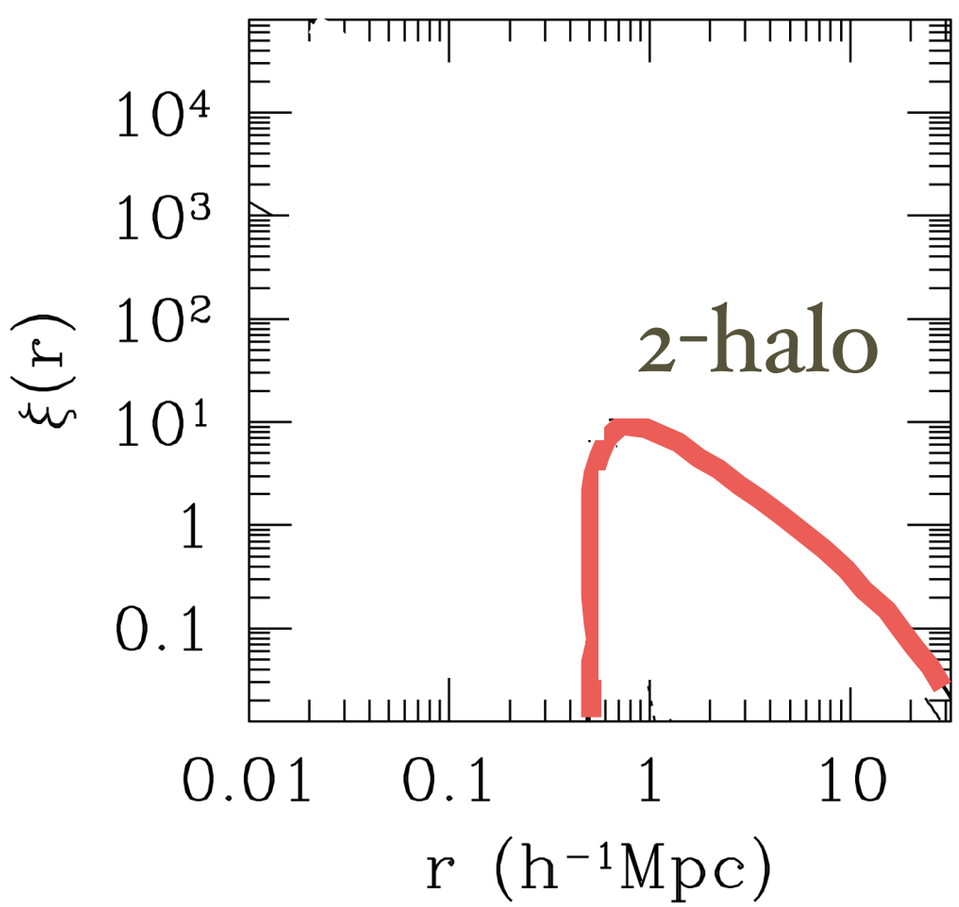
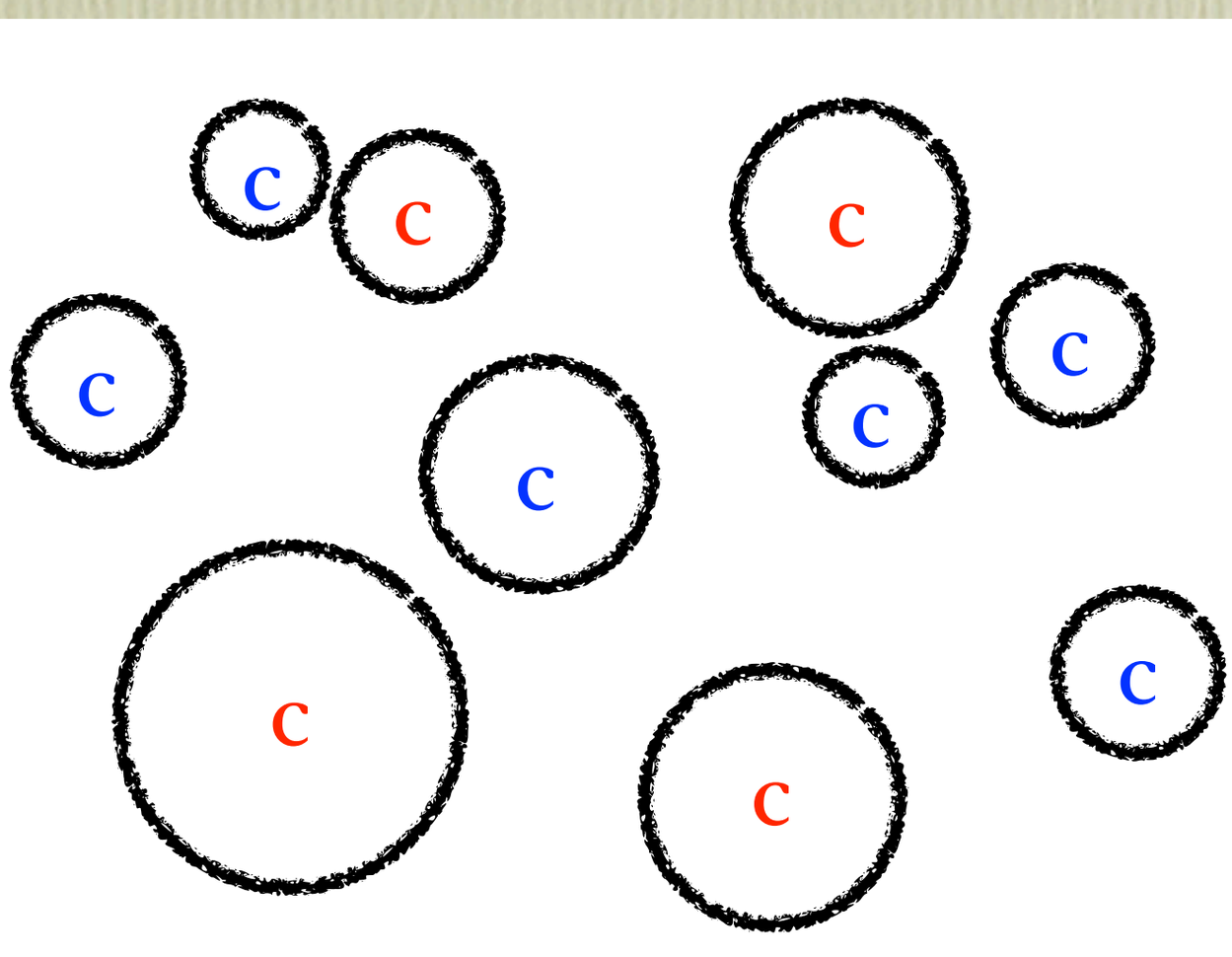
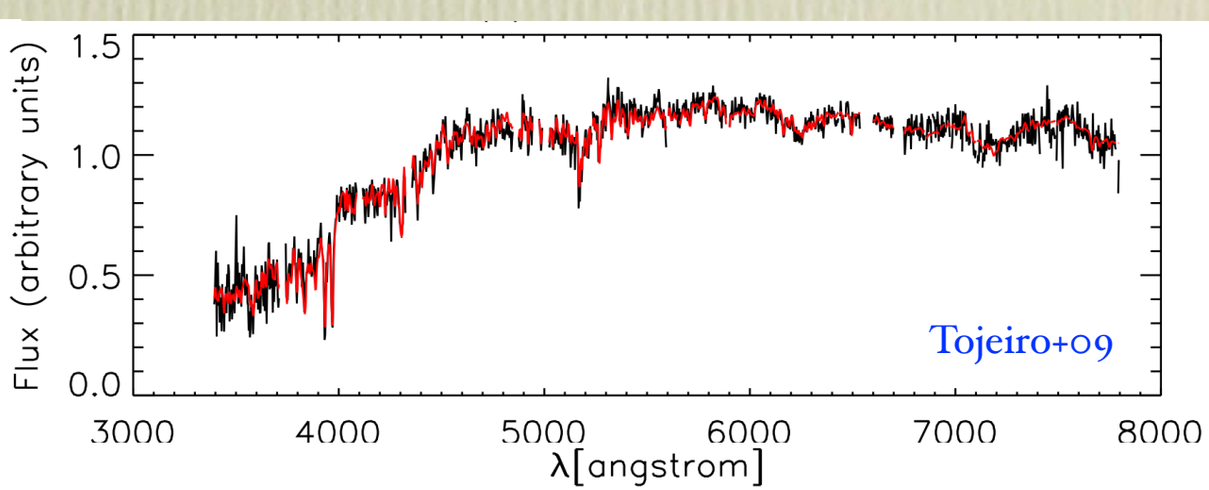
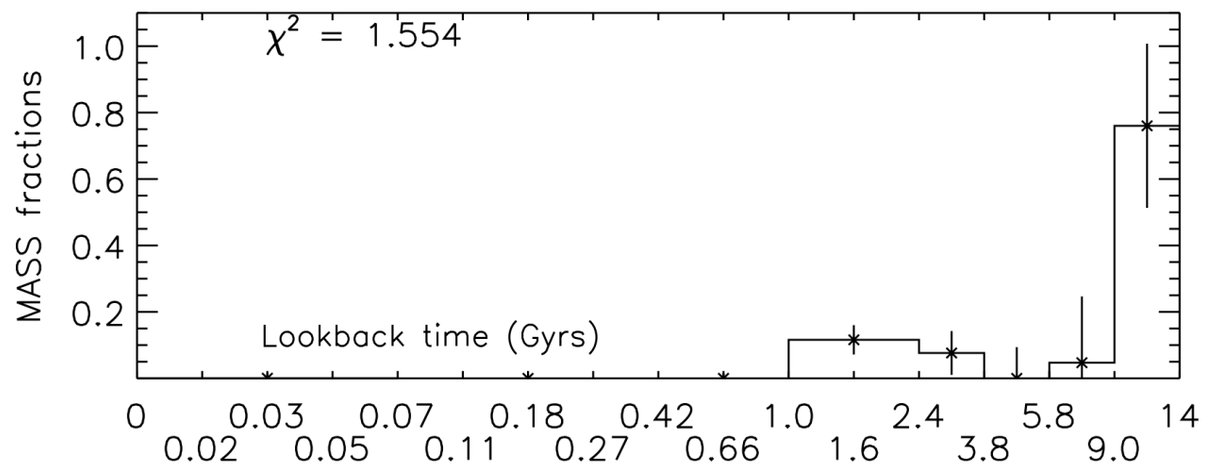

2-halo
10^4
10^3
10^2
10^1
1
0.1
$\xi(r)$
0.01
0.1
1
10
r (h^{-1}Mpc)

our approach

- still use Yang's central galaxy catalog
  - trim off satellites via a friends-of-friends algorithm
  - use weak lensing to ensure samples of early- and late-forming centrals have similar mean masses
- use resolved star formation history from VESPA algorithm to define early- and late-forming central galaxy samples







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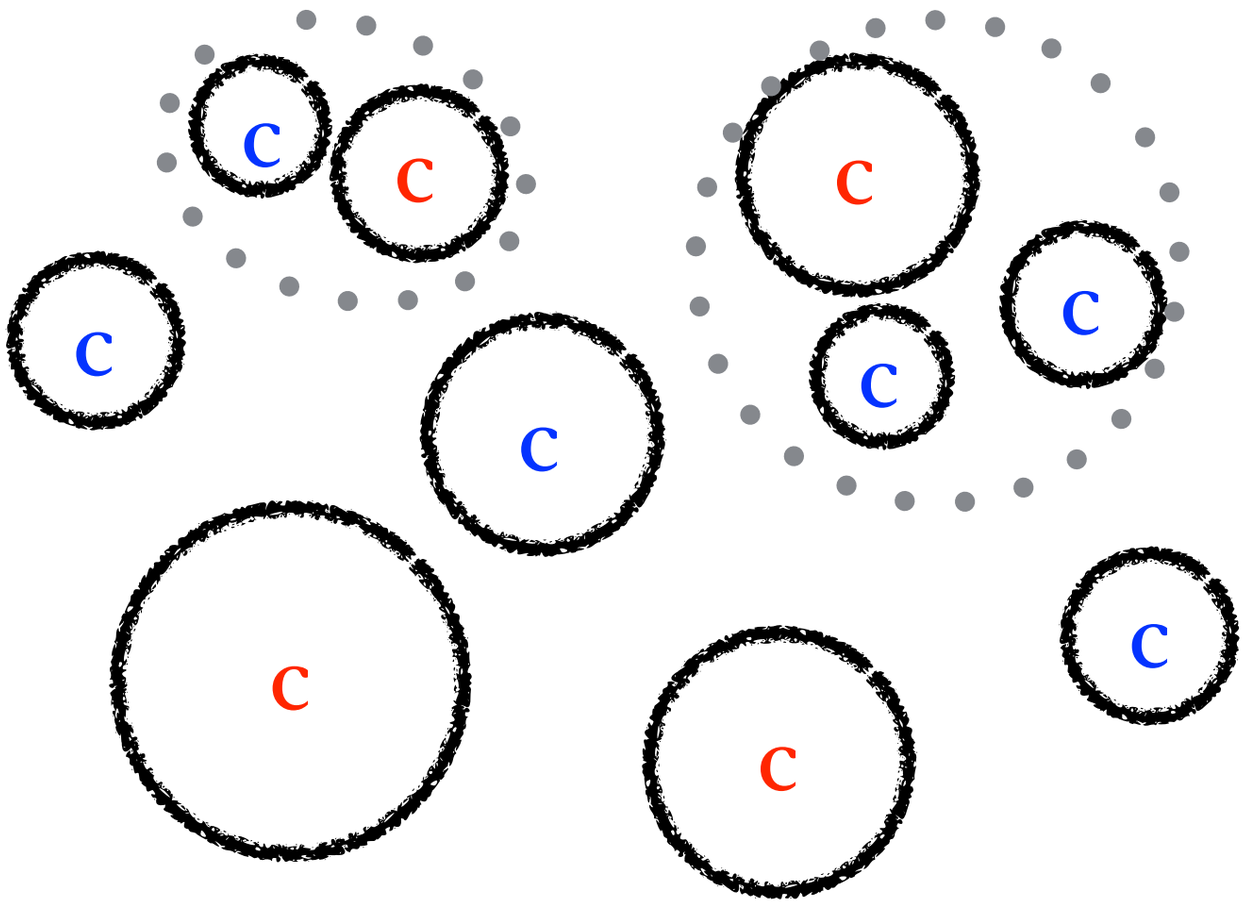

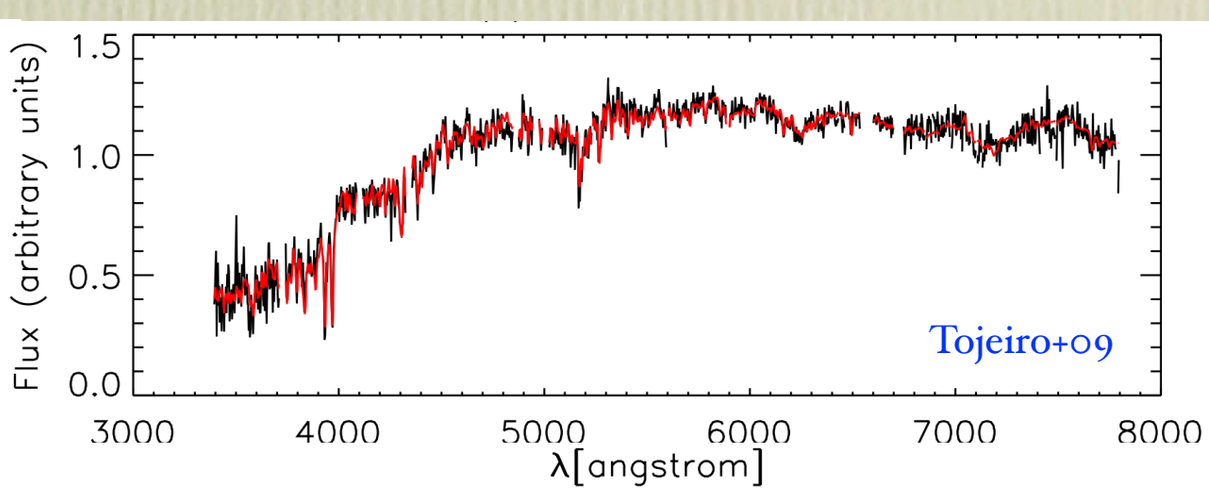

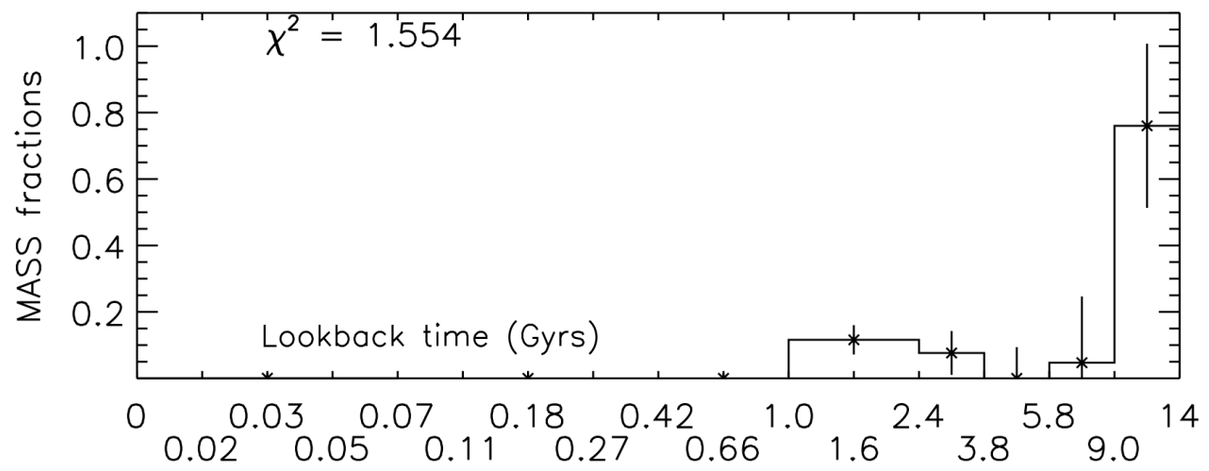

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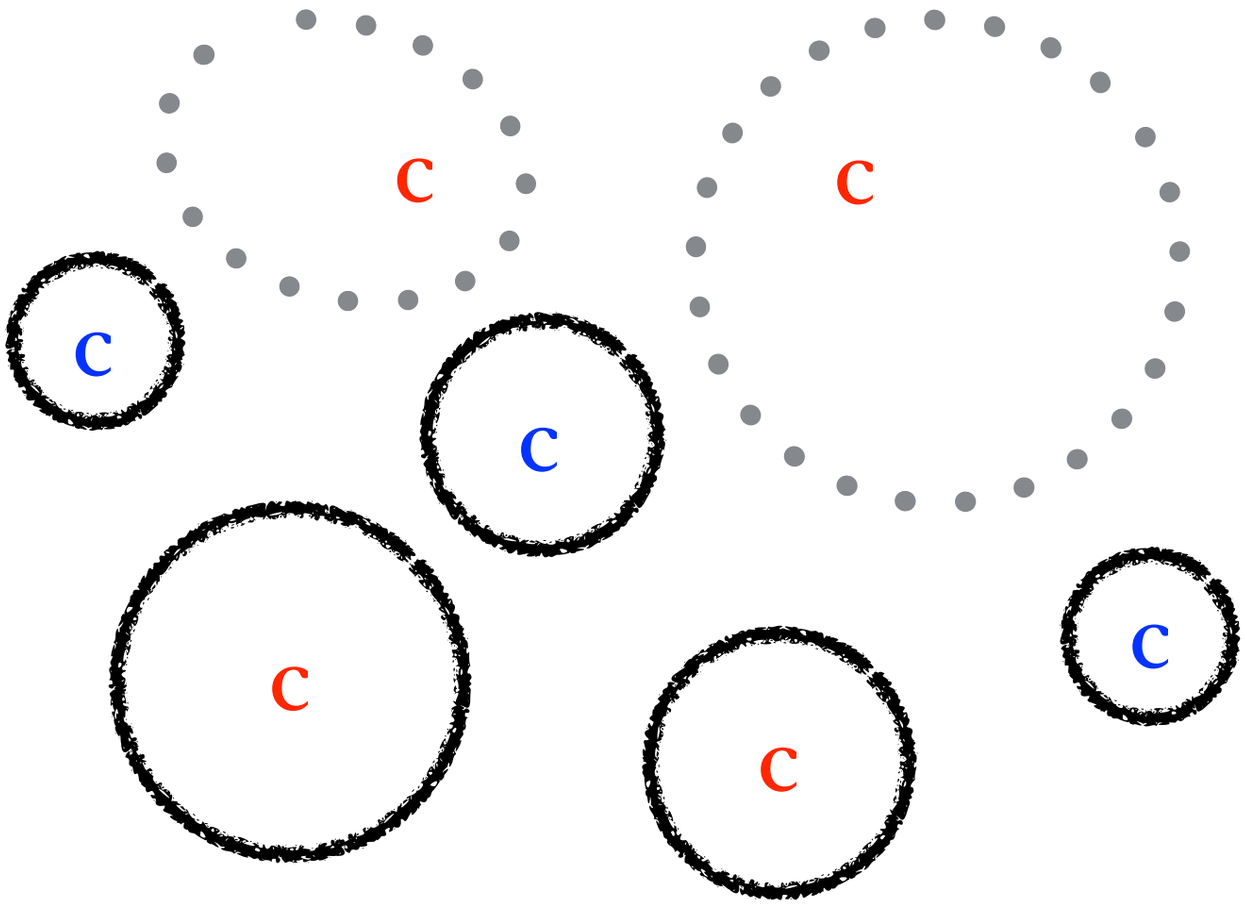
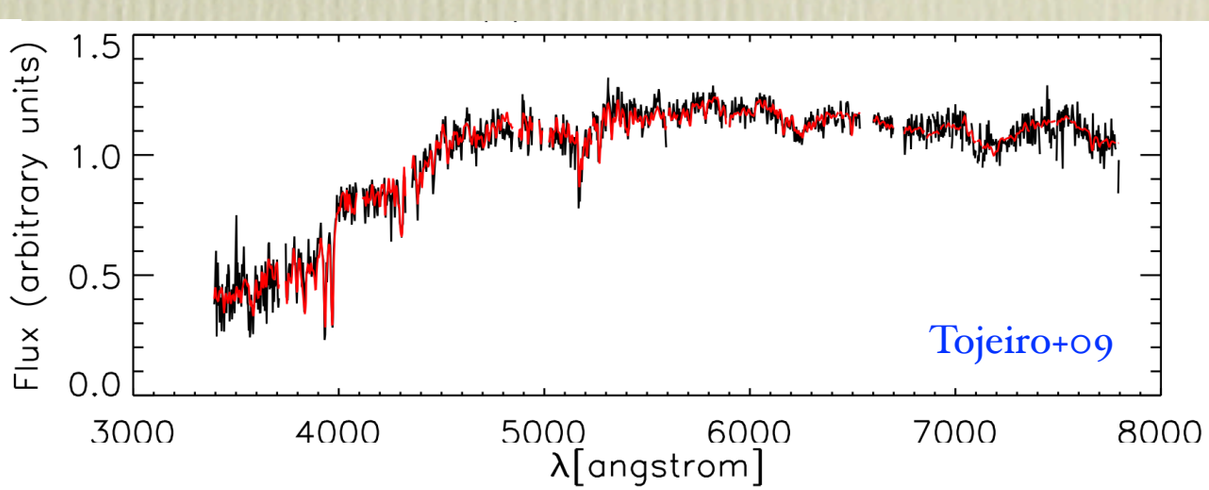
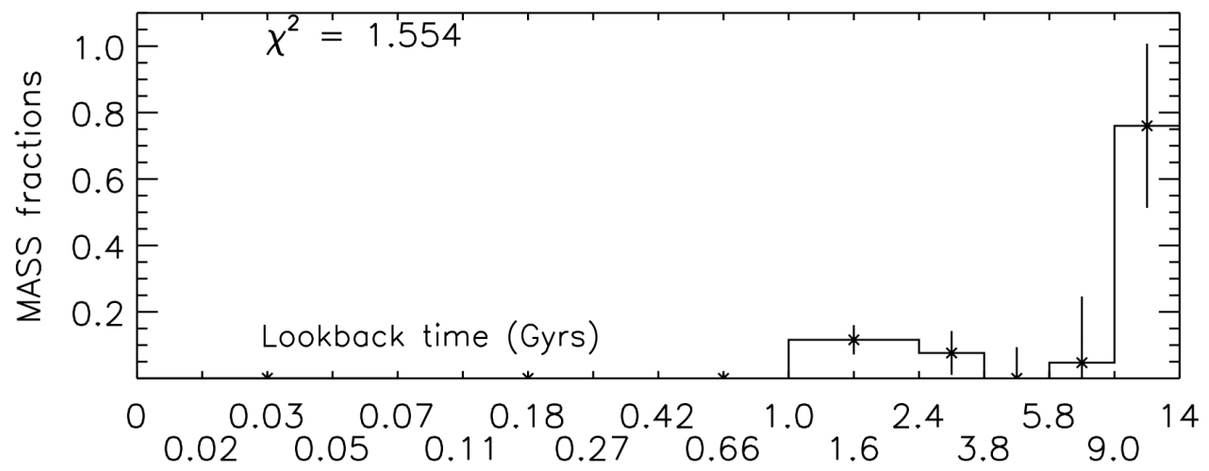
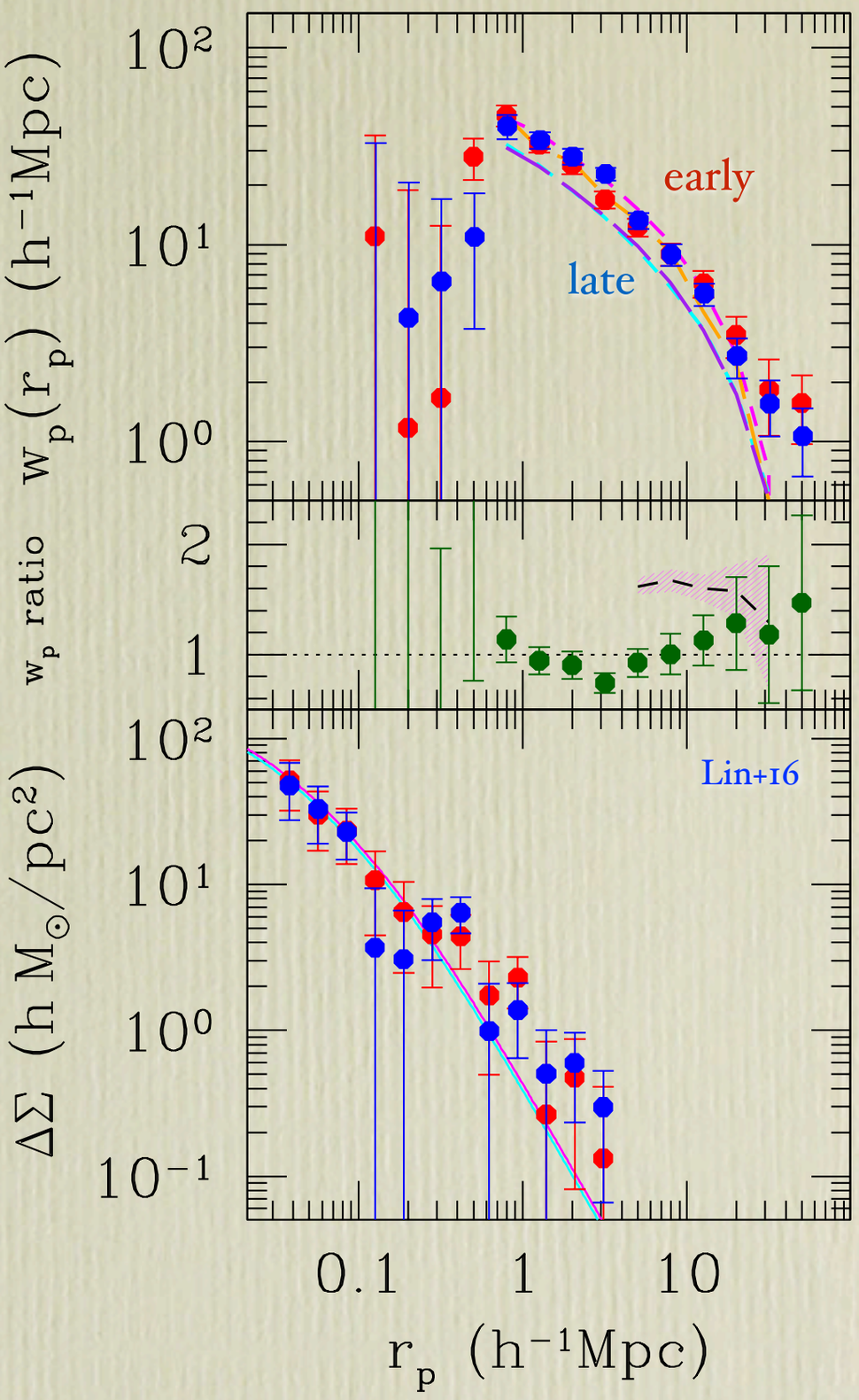






non-detection of assembly bias

- we have constructed a pair of early- and late-forming central samples for which the satellite contamination is minimal
- masses are $(9\pm2)\times10^{11}h^{-1}M_{sun}$ and $(8\pm2)\times10^{11}h^{-1}M_{sun}$
- theoretical expectation derived from high resolution N-body simulations, taking into account uncertainties in halo mass distribution
  - log-normal form assumed
  - probable values of centroid & width allowed by measured lensing signal
- probability for theory to be consistent with observation is 2×10^{-6}



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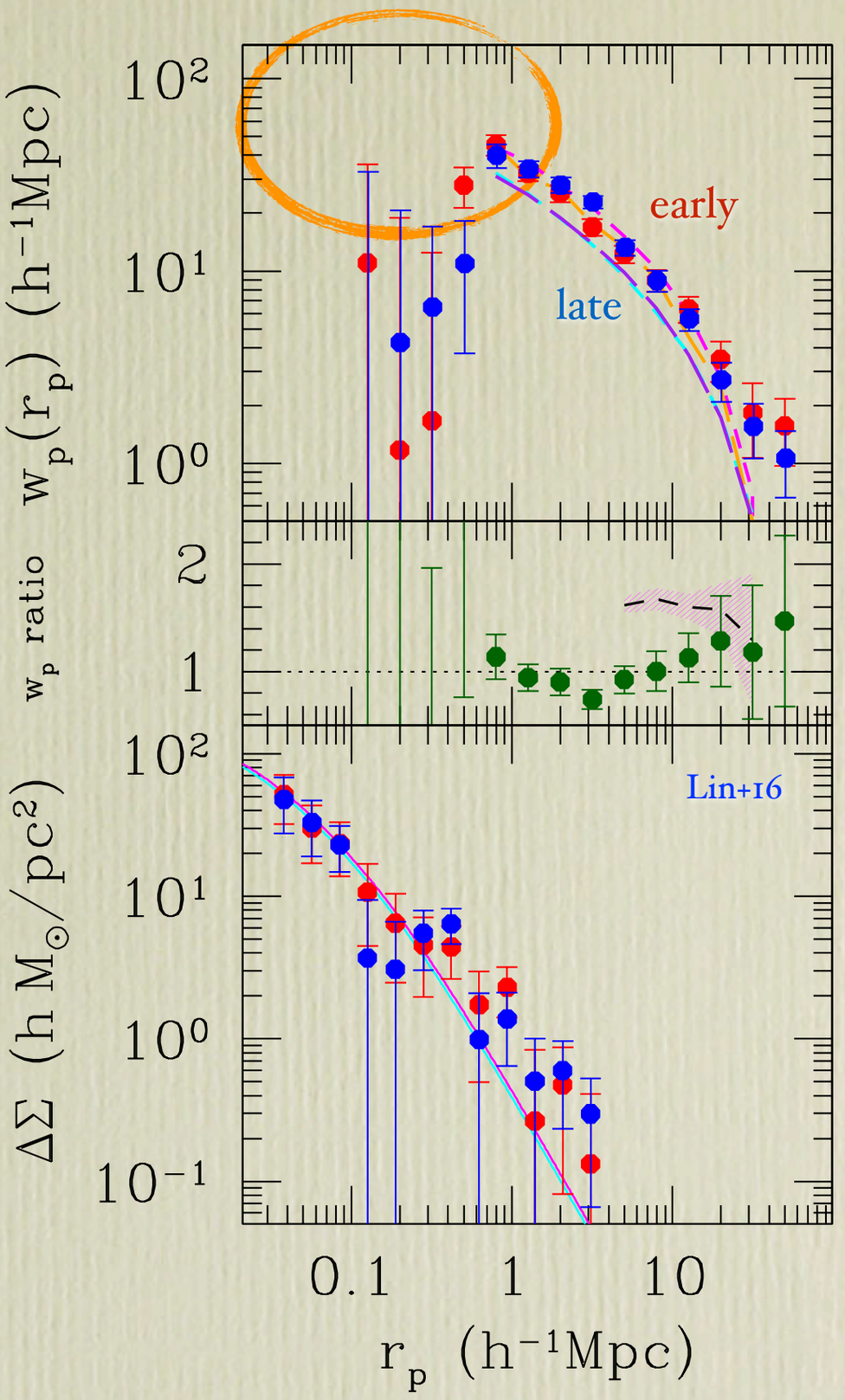

implications

- galaxy formation processes render magnitude of assembly bias small?
  - not according to Guo+11 semi-analytic model
- *VESPA*-based SFH not good enough for subtle effect like assembly bias?
  - may need higher S/N spectral data from future surveys
  - will try other algorithms such as STARLIGHT
- how tightly coupled is central galaxy formation history to that of the halos?
  - actually, quite tight, according to the Guo+11 model
- better proxy for halo formation time?
  - z_{mah} derived for SFH or mean stellar age
  - look at extrema of the distributions
  - concentration?

summary

- no convincing evidence for assembly bias at low mass halo scale
- presumably better age indicator is needed
- or should consider concentration of halos

- at high mass scale, detection of assembly bias is still in progress
- pair of early and late forming cluster samples constructed, with similar masses
- evidence for reduced number of member galaxies, as well as more concentrated spatial distribution, in older clusters ⇒ consistent with expectations from dynamical friction